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ABSTRACT

This paper describes functions of a computer system for management of individualized instruction, details of a computer managed instruction (CMI) facility, the role of the teacher in utilizing a CMI system, and five programs which implement the concept of individualization with computer assistance. CMI system functions described include diagnosing, assigning or prescribing, facilitating study, evaluating, data collection and manipulation, reporting, resource and space management, providing an information network, and materials implementation. The computerized facilities which comprise a system are also described, including materials creation, individualized study/evaluation, records and reporting, resource management, and communication. A brief discussion of the teacher's role in CMI and a review of CMI systems--PLAN, TIPS, CISS, AIS, and TICCIT--are included. This resource for preservice and inservice teacher training includes study activities and a 31-item bibliography. (CMV)

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The Illinois Series on Educational Application of Computers

COMPUTER MANAGED INSTRUCTION
and
INDIVIDUALIZATION

J. Richard Dennis

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To the reader,

This is one of a series of documents prepared as resources for the preservice and inservice training of teachers. The general theme of all items in this series is "teaching with or about computers". The booklets are the collective work of a variety of staff and students (both present and former) of the College of Education, University of Illinois at Urbana-Champaign. The project generously was supported between 1977 and 1979 by a grant from the EXXON Education Foundation. All responsibility for the content of these documents rests with the authors and does not reflect necessarily the views of the EXXON Foundation. It was my extreme pleasure to direct this effort throughout.

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COMPUTER MANAGED INSTRUCTION AND INDIVIDUALIZATION

Computer managed instruction (CMI) was not among the earliest applications to which the computer was addressed in education. However, indications (and predictions) are that, currently, this style of instructional computing is among the most rapidly growing styles. There are several possible reasons for this:

1. Growing realization of the level of effort required to deliver adequate computerized instruction. Early conceptions of instructional use of computers grossly underestimated the complexity of the learning process. They also underestimated the level of hardware and software resources required to deliver adequate computerized instruction.
2. Declining school resources coupled with growing demands for accountability.
3. Early attempts at individualized instruction helped to formulate a conception of the magnitude of the management task required to monitor and to facilitate this style of instruction

The basic idea underlying CMI more or less is self-evident. One of the major roles of the classroom teacher is that of manager. There are two levels of management activity involved in a classroom. One of these is supervisory style management which mostly involves clerical activities that many of us expect to see teachers doing. Functions such as recording, assigning, evaluating, arranging and reporting all are activities known to the classroom teacher. These activities all are, by nature, quite routine but consume rather significant amounts of time.

The second level of management activity required in education is much more sophisticated. It involves the truly managerial functions of planning, organizing, commanding, coordinating, and controlling. Baker (1978) suggests that for computers to have a documentable and justifiable influence in education, the role of the teacher must move away from the supervisory functions and take on the management-level functions described above. To do this, a computer system will be a mandatory support utility. Such a system will require both the capability of assuming most of the routine supervisory functions and an ability to support the management-level functions.

In the following pages we describe the elements of a computer system for management of individual instruction. Then we discuss the role of the teacher in utilizing such a system.

FUNCTIONS OF A CMI SYSTEM

When using the computer in an instructional management mode, the assumptions shift away from attempts to simulate a majority of the functions of a teacher. To do this the computer usually participates instead in the following activities:

1. Diagnosing
2. Assigning or prescribing
3. Facilitating study
4. Evaluating
5. Data collection and manipulation
6. Reporting
7. Resource and space management
8. Providing an information network
9. Materials implementation

Diagnosing

To diagnose a student's progress, one must be able to determine progress toward specified objectives. This has several dimensions. One is determining the pattern to date of successes toward the objective. The other important, and often more difficult, dimension is determining the pattern and reasons for non-success so that remedies may be invoked. Based upon the results of diagnosis, a student may be directed toward a new assignment in the same conceptual stream, a new assignment in a different stream, a remedial assignment in the same stream and instructional mode, a remedial assignment in the same stream in a different instructional mode or remedial assignments in an appropriate instructional mode in a different stream. In each of these cases, correct interpretation of the student's learning profile is crucial to the efficient use of the student's time and the learning resources.

Assigning and Prescribing

This action is a natural outgrowth of the diagnostic function discussed above. Each assignment consists of a specific and appropriate learning activity. Sometimes the assignment choice somewhat logically will be singular as is the case of a common learning difficulty or misconception having a well established treatment. Other times the assignment may reasonably be any one of several activities. The nature of these activities ranges widely to include:

1. Individual practice
2. Text assignments
3. Group activity
4. Teacher consultation
5. Laboratory session
6. Alternate media session
7. Computer-based activity

Although an instructional management system is not directly designed to deliver instruction, it may direct and integrate the utilization of other computerized instruction facilities such as simulations, problem solving, etc.

Facilitating Study

In the conventional classroom, individual study is effected by having students complete a variety of either in-class exercises or homework exercises. In most cases the student may work a long list of such exercises before receiving any information about the correctness of the work. Such study procedures probably are among the more inefficient known.

In a CMI system, one of the most important services to provide the student is a self-study monitoring system. This is a facility designed to give the student immediate knowledge of correctness together with specific help with the correction of errors. Essentially, such a service includes the features of a well designed practicing (questioning) facility (see ISEAC no.4 or ISEAC no.7). This can be implemented in an interactive mode with students going to terminals to participate in the questioning or in a batch mode using mark sensed answering instruments together

with a computer controlled reading device to process and summarize answers and to give corrective feedback. Both of these modes have been demonstrated in existing CMI systems. In the interactive mode, students get feedback on each question as it is answered. In batch mode, the student answers a set of questions and then receives feedback on the items in the set.

The answer judging elements of a self-study facility need to be evaluative but not judgemental or penalizing. In a self-study facility, the student should not be graded on the work but should know how well (s)he has done if grades were to be assigned. This is necessary partly to remove the stigma attached to answering questions incorrectly. Much learning can be derived from incorrect responses when feedback and repetition procedures are designed properly.

Evaluating

In order for a CMI system properly to perform assigning or advising functions, there must be a means for providing the computer both with current information about the student's performance and with a history of performance against which to compare present data. This data may be gathered by an evaluating facility consisting of sets of questions or tasks representing desired behaviors on the various learning objectives. For use in schools, teachers will require some degree of security for evaluation facilities to insure a relatively high probability of actual learning. This security can be achieved through question pooling, where each objective is represented by several evaluation questions of comparable form or appearance.

As with self-study facilities, evaluation facilities for a CMI system may be either interactive or batch in nature. Security provisions are simpler in an interactive mode at display type terminals, since nothing gets printed to be carried away. In batch mode, the instructor may provide the security for printed tests with alternate forms. Students are given the tests under supervised conditions either individually or in groups as conditions dictate.

Data Collection Reporting

As you can see, most of the functions of a computerized individualizing system will not operate without extensive data. The quality of both system performance and its decisions are dependent upon a wide variety of information. Teacher-managers will want this data aggregated in a variety of ways, sometimes about an individual student, sometimes about particular groups of students, sometimes about individual learning activities, sometimes about groups of learning activities, and most of all, about effectiveness of the decisions the system makes.

Reporting also must be available on a wide variety of levels. Reporting to students to assist study is different from reporting to students results of evaluation. Each of these levels is different from reporting to a teacher, to a parent, to a school administrator, or to appropriate governmental agencies. Of course, the data facilities must be secure to insure the proper (and legal) balance between information access and individual privacy.

Resource and Space Management

In the conventional classroom, the teacher makes all arrangements to get students and learning materials or equipment together at the proper times and places. If a particular resource is less numerous than the student population needing access to it at one time, sign-up procedures or other scheduling provisions must be instituted. Of course, all of this arranging takes time. And time is spent on an activity of the clerical-supervision type, rather than on tasks demanding a well trained, experienced teacher.

As described above, a CMI system would assume major responsibility for deciding when each learning activity of an instructional program should be assigned to any one student. The record keeping facility of a CMI system would report this assignment to the teacher as needed. If, however, the CMI services stop here, then little of the clerical-supervisory activity has been accomplished for the teacher. Instead, the CMI system not only should know what assignments to make to students and on what conditions to make them but also should know what resources are needed for each learning activity, the numerousness of these resources in terms of numbers of students that may use a resource at one time, and the spaces available in which to use these resources. With such information, the CMI system facilitates and regulates the making of appointments with whatever resources are needed by the student. In so doing, a CMI system

should attempt to concentrate uses of a resource by several students to minimize set-up labor where it is required. A CMI system also should prevent too many students from being assigned to a limited resource at a time. To do this, the computer needs information about alternate assignments appropriate when a particular resource is saturated.

One of the resources needing the greatest amount of management is the teacher. A CMI system is not intended to eliminate contacts between the teacher and the student and individualization of instruction does not imply the demise of group activities. Each of these activities still will be present in a computer managed, individual environment. The regulation of these activities must be a function of a CMI system to a significant extent. Students must be able to get access to the teacher for consultation and the teacher must be able to initiate individual consultations with a student. In a self-contained individual environment (such as an elementary school classroom), computer management of the teacher and teacher centered activities may seem like over-kill. However, in less confined environments such as secondary schools, community colleges, or technical schools, procedures for arranging contacts between the teacher and single or groups of students, regardless of the initiating source of such contacts, are a must.

Providing an Information Network

One of the little recognized functions of a classroom teacher is as a clearing and control point for information among many different sources. Teachers who have attempted individualized instruction either under their own efforts or with the aid of an incomplete CMI system quickly come to realize the magnitude of this role. Announcements of events that involve a group of students and messages to particular students suddenly require more conscious attention by the teacher. As students begin dispersing themselves around an extended learning environment these problems are magnified greatly. This weakness of teacher-managed, individualization programs, or of poorly designed CMI systems, may account for the frequently reported feelings of the teacher of being "out of touch" with the students in these alternative instructional plans.

A remedy for inefficient information flow procedures in an individualized environment is a computerized mailbox. The concept is the same as the ordinary mailbox--an individualized depository for information from other sources, to be accessed at will by the owner. In CMI systems, this facility is controlled by a computer. Messages from one individual to another are recorded for retrieval by the appropriate persons. Messages to a group of people are

reported in an automated bulletin fashion to those people. Such facilities are important particularly when individualized instruction involves a larger number of people and an extended instructional environment with students more in control of all of their work time.

DETAILS OF A CMI FACILITY

A computerized instructional management system is a unique environment possessing certain attributes. This unique environment will not function without a large amount of specific information to process and to present to its users. The majority of this information must be created before the CMI system ever can begin to participate in instructional management. The rest of the information is gathered during operation.

Information required prior to commencing operation generally falls in the category of curricular materials. A curricular flow plan includes bases for decisions on choices of alternatives (branches) in the curriculum. Details of all assignments and the needed resources are necessary, as are all the questions to be used in diagnosing, providing self-study, and evaluating. The teacher faces two tasks in this respect when initiating a CMI effort. First, there is the gathering, creating, and organizing of the curricular plan, all of its elements and the means of all its decisions. Second is the task of "teaching" the curricular plan to the computer, that is, of making all this information executable by the CMI system.

In the latter task, the CMI system itself can be a support facility if properly constructed. What is needed is a simple means of entering into the computer text material, questions, assignments, objectives, descriptions of decision points, information on which to base decisions, and various evaluation criteria. This is a function of a specialized materials authoring facility (usually called an authoring language). For optimum applicability, such a facility should require an absolute minimum of computer programming training. Hopefully, the facility would function so that a clerk could enter the information from detailed hand-written or dictated descriptions.

From the preceding discussion of the functions of a CMI system, we can define the following computerized facilities comprising such a system:

1. Materials creation facility
2. Individualized study/evaluation facility
3. Records and reporting facility
4. Resource management facility
5. Communication facility

In this section we give the details of each such facility from the view of the computer and of the various people who must use it.

Materials Creation

The curricular information required by a CMI system to work in an instructional setting consists of objectives, assignments or prescriptions, many questions for several purposes, and details of a network organizing such information and defining many paths for traversing the network. Generally, all these can be presented to a CMI system with an authoring facility containing easy means of creating each of the following:

1. Text
2. Question episodes (questions, correct answers, specific incorrect answers, replies to each type of answer)
3. Student decision points (define choices for student, permit choice, branch based upon choice)
4. Computer decision points (create computerized branch points and label destinations)

The computer initiated decision points may need to include both the ability to alter paths within a defined unit of instruction and the ability to cause an exit from one defined unit and the entrance of another (called chaining). In the latter case, the units of instruction may be either units as defined in the CMI system itself or other computer programs tied into the curricular network.

Along with the capability initially to create each of the above curricular elements, a CMI system also must have an easy means of changing or eliminating existing elements. These are editing features found in varying degrees on computers and in CMI systems. Minimally, a CMI system must permit:

1. Alteration of existing letters, words, or lines of information.
2. Insertion of new letters, words, or lines anywhere among existing ones.
3. Deletion among existing material without disturbing adjoining material.

Of course, the alert reader will realize that if a system permits deletion of old material and insertion of new material anywhere in curricular units, then the ability to alter already exists. In fact, however, computerized altering can be much more than deleting followed by inserting. When altering a line of information for example, only a few pieces of it may be faulty. In such cases, the better computerized editing facilities perform copying of the acceptable parts with alteration only to the unacceptable parts.

Individualized Study/Evaluation

The individualized study facility of a CMI system is the student's interface with the curriculum defined by the teacher. This is the student's means of getting appropriate assignments and of facilitating his own learning with appropriate self study services. There are two basic modes for this activity, batch or interactive, and reputable CMI systems exist for each.

In batch mode, assignments are given through a printing terminal (like a Teletype or DECwriter). These include references to printed self study booklets. The booklets contain information text and questions to be answered. These answers are recorded on a computer readable answer form (a card or a sheet). The form may be self revealing in that, as the student marks an answer box, a code is revealed to tell if the answer is correct. Included in this material may be self tests over the objectives. Once completed, the student takes the answer form to a mark-sensed card or page reader. The computer gives back scores on the activity and further assignments on the objectives based upon the profile of errors when performance is weak. Otherwise, the computer gives the name of a test booklet on those objectives which the student might secure from an aide. The test also is taken with mark sensed forms, read and evaluated by the computer, and followed by assignments to remedial material in order to increase performance, or by assignment to new material.

Batch mode CMI requires facilities away from the computer for housing large quantities of study and test booklets. Also, auxiliary personnel usually are used as aides and test monitors.

In interactive mode, probably only assignments will be executed away from a computer terminal. All other questioning will take place on-line. This eliminates the need for extensive printed materials but introduces a need for many more terminal devices to accommodate the same audience. To be effective, interactive systems must be designed to permit students to quit work both within units and between units and to resume appropriately next session.

Regardless of the mode of interaction with the computer, an individualized study facility should have provision for both attaining achievement of the objectives and for maintaining achievement over a period of time. These two levels of study are distinguished by point in time. One is attaining achievement of an objective up to the point of a number of successive successful completions of the criterion tasks for that objective. This number may vary from objective to objective and is one of the parameters the teacher should be able to specify with the curriculum information. Once this event has occurred, the student is in the maintaining achievement stage of study. During the attaining stage, study sessions will be confined to tasks of particular objectives, those currently under investigation. The questioning strategy of the CMI system must be two-fold:

1. A systematic cycling of tasks on which the student initially is successful to increase the probability that such success truly represents learning.
2. A systematic, more frequent cycling of tasks on which the student is at some time unsuccessful to correct these behaviors and, in turn, to increase the probability that the new behaviors have been learned. These will be recognized as the major attributes of effective design in drill or practice situations (see ISEAC no.7e).

Once initially achieved according to the criteria, the objective is put into a set of "needing periodic review" objectives. The length of the period depends upon several attributes including (1) difficulty experienced during the attaining stage, (2) the pattern of success on the objective's tasks after achieving the attainment stage (low success during a review session increases the frequency of review thereafter) and (3) the relative importance of the objective in the entire curriculum. Generally, the pattern of design for achievement maintenance sessions is to select several of the attained objectives most likely in need of review and to build the practice sessions around tasks for these objectives. This can be done entirely by the computer using pools of questions for each objective and drawing from each pool randomly from session to session. More simply (perhaps for smaller computers) the objectives needing review would be told to the student, who would assume responsibility for selecting practice activities for these objectives from an index (or menu) of such activities.

This discussion implies that the maintaining achievement mode needs two sources of input for controlling the likelihood of objectives needing review. One of these is the student's desires to review particular objectives. A good individualized study

facility will permit student initiated review at any time. The other source of control over maintaining achievement is generated within the CMI system as a function of:

1. Profile of past successes on the objective.
2. Need to review prerequisites for a future attainment of new dependent objectives.

These latter relationships must carefully be planned by the teacher as the curricular materials are being built.

The extent to which the student is given responsibility over decisions involving curricular flow is an issue. In a review of the research on student control of study, Steinberg (1977) summarizes that two problems usually are noted when students are given total control over course flow. First, students tend not to initiate adequate review procedures for themselves. Second, students in total control tend to use time very ineffectively. This is exhibited in individualized settings by low completion rates, long periods of no activity followed by short periods of frantic effort (the procrastination phenomenon), inefficient use of the facilities provided, etc. So far, studies seem to indicate that these characteristics are most prevailing among least successful students, an observation which should come as no surprise to a classroom teacher.

Records and Reporting

The records facility of a CMI system is the means of collecting, updating, alerting, and summarizing information on everything and everyone in touch with the system. For the teacher, the following tasks must be easily accomplished:

1. Specify course parameters and student data to be kept.
2. Enroll students and enter prerequisite data.
3. Secure individual student records.
4. Alter a student record.
5. Secure records on curricular events or objectives.
6. Define form of needed reports.
7. Initiate reports as needed.

Students wish to review personal records from time to time. Early in their CMI experiences such investigation will be more frequent by those students lacking confidence in an automatic system. Some of this concern and exercise of responsibility over the contents of files of personal information is behavior worthy of encouragement for living in an electronic world. Others in the instructional setting may need specialized summaries of data in order to perform necessary preparations for future activity. In all these cases, the data should be (1) easy to get, (2) available only to those authorized, and (3) available in easily interpretable form, preferably with implied decisions already noted to the extent that such are predictable.

Resource Management

A resource facility of a CMI system has the following general functions:

1. Maximizing use of space, equipment, and other instructional materials.
2. Minimizing time lost due to delays caused by an unavailable instructional resource.

School resources more and more are becoming like precious gems to teachers. Budgets are being restricted and the first place these restrictions are felt is in the supplies and equipment category. In such a climate, it becomes increasingly difficult to provide resources on the one-to-one basis with a class population. Purchasing less than classroom sets of resources raises other problems, however. Detailed plans must be made, and alternate activities invented, to avoid having several students wasting time waiting for a resource to become available.

The solution to resource scarcity is careful management. However, for the teacher to engage in all the required functions by hand would be a tremendous waste of instructional talent and time. Hiring clerk-type personnel to take care of these details defeats the purpose of restricted budgets--one might as well spend the money for more of the resource.

A CMI system with a resource managing facility addresses these problems. To be sure, one would not justify buying a CMI system just to avoid spending money on instructional resources. However, where an instructional computing system exists or one is being purchased for a variety of other reasons, the increment of efficiency that may be derived by adding resource management to other intended uses is a definite benefit.

The basic ingredient of a resource managing system is an appointment scheduling and optimizing service. From the teacher's point of view, such a service must permit specification of a variety of types of appointments. Some activities require half an hour, others require two hours, some can accommodate one person at a time, others can be pursued by several students at a time. These specifications or parameters should be easily definable and should be maintained for extended periods of time. The following

list illustrates the variety of appointments that might be needed in a fully individualized mathematics class:

1. Use of supplemental text resources--single appointments in multiples of one-half hour.
2. Use of audio-tutorial facility--up to six per time unit, in multiples of 15 minutes.
3. Film projector in small viewing room--up to (room size) per time unit, in multiples of 15 minutes.
4. Math laboratory for quantitative experiments--two per station, multiples of one-half hour.
5. Outdoor measurement or data gathering activities--three at a time, multiples of an hour.
6. Student initiated instructor appointments--one at a time, multiples of 15 minutes.
7. Instructor initiated group conferences up to (room size) per time unit, multiples of one-half hour.

The time multiples are illustrative only. The point is that a resource management facility should permit the teacher quickly to specify at least this kind of varying appointment information.

The major users of a resource managing facility are teachers and students. Each of these people should be permitted to do the following types of tasks:

1. Make any of the types of appointments.
2. Review personal appointments for a particular time or for a particular activity.
3. Change or delete personal appointments.

For all of these tasks, the resource managing system should preserve the basic principles of keeping resources in (nearly) continuous use and of keeping people active on productive tasks.

Beyond these options for all users of the CMI system, there should be an option for the teacher to block out days or time periods from appointments as more local events become known. When such is done, the system at least must provide information about

appointments that already have been made so that such information may be directed to the appropriate people for necessary action.

Communication

If you have attempted or experienced individualized instruction yourself, you realize very well the communication problems that arise as the group procedures of a classroom disappear. As students develop more and more independence and expand the physical settings and time frames in which they do their work, communication with others in the instructional program becomes still more troublesome.

To alleviate difficulty in getting information passed among participants of a computerized individualizing system, a mailbox facility is needed. Such a facility permits any person in the context to deposit a message for any other person or group of persons in the context. Each person then receives personal messages by signing into the mailbox facility.

A message facility should provide at least the following types of services

1. Enter and edit a message.
2. Send a message to one person.
3. Send a message to several persons.
4. View messages sent to you or to a group including you.
5. Delete any messages sent to you.

More advanced mailbox systems have one or more of the following additional features:

1. Forward a message to another person.
2. Establish effective dates for a message.
3. Automatic deleting of messages after effective dates are past.
4. Printing of a received message on a paper printing device.

Still another message feature available on more sophisticated CMI systems is the ability for two people to "converse" between terminals. In this mode, an individual may review a list of people currently using the system, may page any one of them, and the two people engage in an interactive conversation through their terminals. The usual procedure for this uses a screen type terminal and displays the message of each party on a different part of the screen. Each conversant's screen shows both parties' communications.

TEACHER'S ROLE IN CMI

As was mentioned earlier, the role of a teacher significantly changes when a CMI system is instituted. Generally, the usual supervisory and clerical activities should become the responsibility of the computer system. The teacher, in turn, must pay much more attention to planning, organizing, commanding, coordinating, and controlling.

Before a CMI system can begin to function, it must be "taught" a curriculum and the bases for, and consequences of, a variety of decisions. To do this, the teacher carefully must plan and prepare the information that defines the curricular network and all of the components included in it. The scope of this task is illustrated by the following list of questions for which the teacher should possess detailed answers:

1. What are the instructional objectives?
2. What are the prerequisites of each objectives?
3. How will mastery of an objective be determined?
4. What type of curricular flow will be used (student selection, fixed sequence, or adapted by individual performance)?
5. Where are remedial or help resources likely to be needed?
6. What remedial or help resources are available at each point?
7. What action is to be taken when no more remedial or help resources are available?
8. What information about performance is to be gathered?
9. How is information to be processed and reported?
10. What pacing procedures are to be used and in what conditions?
11. What type(s) of testing is (are) to be used and how often?
12. What are the criteria for testing?
13. What resources will be used in study?

14. What resource scheduling will be needed?
15. What are the constraints on loading of the resources?
16. If grades are used, how and when are they to be assigned?

This is not intended as an exhaustive list, only illustrative. Many of these questions must be answered by giving detailed descriptions or lists of specific question episodes to the computer system.

The message that should be clear for the teacher is to start CMI efforts at a very low level, with only selected services offered at first. Above all, avoid overadvertising what you can provide at first. If a complete CMI facility already exists for each subject or class, these considerations would not be a problem. But such is not to be the case for the present.

The second message that should be clear is that the teacher will more than have his hands full with the curriculum specific preparations for CMI. He will not be able to create the CMI system software itself. It must be obtained from an external source. Sometimes the software will come with a purchased computer. Sometimes one can get it from another school (but be careful of copyright rules).

For most teachers commencing implementation of a CMI system, their students will have had little experience with individualized instruction and the concomitant personal responsibility for study decisions. This can create many problems in the early weeks and months of such attempts. For example, an interactive self study activity for a particular assignment may find a student sitting at a terminal, with a textbook in lap, flipping pages to find the answer to each question asked. This procedure is very inefficient for the student and is wasteful of the computer resources as well. Students should try to compress in time their execution of a set of study questions. They need to realize that for questioning activities which are not graded (only scored) there is merit in answering questions incorrectly in order to learn of the corrective feedback and, perhaps, consequences of the incorrect responses.

During the time span of a CMI course, the teacher should watch for opportunities to gather small groups of individuals together for discussions. This will not be as difficult as one might imagine. Although potentially, students could scatter themselves in the curriculum network so that no two of them are at the same place, in practice this tends not to happen to such an extreme. Even in learning activities, people are very social

animals and cluster themselves together to talk about what they are doing. Beyond this, the teacher should organize sessions in which sets of students get together to talk about their work and what they are learning. Present day CMI systems cannot engage in oral discussions and interchanges. Only people can do this and it is an important activity of learning. Learning individually should not be confused with learning in isolation.

SURVEY OF CMI SYSTEMS

Here we present descriptions of several efforts to date to implement the concept of individualization with computer assistance. This list is by no means exhaustive but is designed to illustrate the variety of attempts in various instructional settings.

Program For Learning In Accordance With Needs (PLAN)

The PLAN individualizing system was developed by Westinghouse Learning Corp and was based in Iowa City, Iowa. This system provided no interactive study management of an immediate variety. Rather, study testing activities were administered and answered in a machine readable form. Student work on such activities was transmitted to a central computer where evaluating took place. The system kept a record of student progress and, for each activity processed, issued an individual program of study which was reported to the participating school the next day.

Teaching Information Processing System (TIPS)

Originating at the University of Wisconsin, the TIPS was designed and implemented in the context of undergraduate economics instruction. In this system, students took survey type questionnaires over their study in the course at the rate of 6-10 times per semester. These were completed on machine readable forms. The answer sheets were processed by a computer which performed diagnosis and reported prescriptions. For the student, a report included question choices together with the correct response, a score and description of level of achievement. Included in the report were a detailed list of prescribed activities as required or optional and a date each assignment was due. These prescriptions ranged from homework assignments to lectures by instructors outside the course.

Also issued by TIPS were reports to teaching aides or assistants that included lists of students together with surveys taken and assignments made. The system also provided information on students who had been recommended for special help. Item analysis of the surveys was included in this report.

The third report level of TIPS was to the instructor who received a summary of both the student and the assistant reports. Also included in the report to the instructor was student initiated feedback on opinions about the study system.

Computerized Instructional Support System (CISS)

The CISS originated at New York Institute of Technology and was an attempt to build a general system applicable in a variety of curricula. CISS performed evaluation of student progress and provided immediate progress reports to the student, with less frequent reports to the instructors. The system attempted to maintain and to relate information about the instructional objectives, the students and their progress, the curriculum, instructional facilities, the various strategies of instruction, and data from tests. This information was processed to evaluate student progress, to prescribe future instructional activities, and to validate and optimize the instructional plan.

Advanced Instructional System (AIS)

This system is one of several instructional management systems growing out of military training. Originated by McDonnell-Douglas Corp under a contract with the U.S. Air Force, the system was designed for large scale instructional settings. The major goal of the effort was to demonstrate significant cost reductions in a variety of training programs. The system incorporated both interactive instruction and batch managing techniques. The interactive terminal featured extensive graphics capabilities used by students in simulation activities and in adaptive testing (one of the major sources of cost savings). Under an adaptive testing model, the computer attempts to match question difficulty to the achievement level of the student. Research on this model indicates that when this match is accomplished, significantly fewer questions need be answered in order to assess student performance.

The AIS also included management terminals composed of an optical mark sensed page reader and a printing device. This was the major control center for instruction, providing the student with answer grading services and with prescriptions for further study. Also, the system attempted to profile student production of study to determine when a person varies from a calculated "normal rate" of study.

Hazeltine TICCIT System

The TICCIT system originally was developed by a team of researchers from the MITRE Corp., a non-profit research company, and from Brigham Young University. Initial development was supported heavily by the National Science Foundation. Hazeltine

Corp. was selected in 1976 to market the system for educational purposes. The TICCIT system provides the user with a course authoring, delivery, and evaluation system for individualized instruction. An authoring language (called TAL) is used to prepare a wide variety of instructional styles, including questioning and simulation, and to control instruction through a variety of training devices such as flight simulators. Materials authoring has been structured to minimize background required by the user.

Other advanced CMI features of the TICCIT system include communication interactively or by mailbox, multi-media instructional control, extensive data gathering, adaptation of instructional flow.

SUMMARY

Computer management of instruction rapidly has grown in incidence and sophistication since 1970. CMI systems are capable of providing a wide variety of managing services ranging from facilitating study to providing for interpersonal communication. However, despite all these advantages in systems and controlling software, little is available in courseware for such systems to manage. For the teacher considering implementation of individualized instruction, the messages are several: (1) start with existing computer managing software--good systems are available and take tremendous effort to duplicate; (2) concentrate on detailed planning for individualization and implement your plan in small, carefully selected increments; (3) design materials so that more sophistication and detail can be achieved without rewriting all previous work; (4) expect your students to behave somewhat irrationally in the early transition from conventional instruction to individualized plans.

This last point is most important. Students in today's schools are accustomed to having all (or nearly all) instructional decisions made for them. In an individualized mode, many decisions are shifted to the student. In such a situation, many students are unable to make the adjustment. They need to be taught how to study with an interactive instrument because it is not like studying a textbook. They also need to be helped to learn how to pace their learning activities reasonably. The computer managing system can play only a small role in these tasks.

STUDY ACTIVITIES

1) For each of the references by (1) Baker (2) Grate, Rueve, and Moore, (3) Scanlon and Connolly, and (4) Allen:

1. List what the author indicates is the basic functions and/or characteristics of a CMI system.
2. Tell what distinction the author makes between CMI activities and instructional presentation activities. List examples of activities for each of the two categories.

2) From your experiences with the subject you will teach, make a list of specific resources that will need managing in your classes. Include estimates of the availability of each, the expected pattern of use, and other details needed to automate such management.

3) Develop a small network of instructional events for a unit of your teaching subject. Using the CAISP system (described in ISEAC no.22e) or a similar system, implementing this mini-network to get experience with authoring and other teacher utilities in a CMI system.

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